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## RESEARCH MEMORANDUM

TANK SPRAY TESTS OF A JET-POWERED MODEL

FITTED WITH NACA HYDRO-SKIS

By

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RESEARCH MEMORANDUM



TANK SPRAY TESTS OF A JET-POWERED MODEL

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SUMMARY

Tank results are presented for take-off tests with a powered dynamic model of a hypothetical jet-propelled high-speed airplane fitted with NACA hydro-skis and having flush turbojet intakes on the upper part of the fuselage near the nose. The possibility of making take-offs without spray entering the intakes, the effect of turbojet air inflow on the tendency of spray to enter the intakes, and the effect of jet power on trim were investigated. It was concluded that take-offs can be made without spray entering the intakes by the use of very small longitudinal strips. The tendency of the turbojet air inflow to draw spray into the intakes is slight. Jet power increased trims during the high-speed part of the take-off run.

INTRODUCTION

The results of the investigation of retractable planing surfaces, called hydro-skis, used to support high-speed jet-propelled water-based airplanes during the high-speed parts of their take-off and landing runs were presented in reference 1. One of the questions presented in this reference was that of the possibility of making take-offs without spray entering the turbojet air intakes. An investigation of that possibility is covered in this paper.

In the present investigation, the effect of air inflow on the tendency of spray to enter turbojet intakes and the effect of jet power on trim were determined in Langley tank no. 2 during October 1947. Tests were made using a  $\frac{1}{12}$ -size jet-powered dynamic model of a hypothetical transonic airplane which had twin flush intakes on the upper part of the fuselage near the nose. The airplane is described in reference 2.

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## TESTING PROCEDURE

The configuration of the model and skis was the same as that reported in reference 1 except that the new model included a jet ducting system and an ejector operated by compressed air, to produce both jet thrust and air inflow. This configuration is shown in figures 1 and 2, and the jet power plant is shown in figure 3. Strips of various types and lengths were installed as shown in figure 4.

Tests were made at constant speeds both with power and without power. Trim of the model and rise of the center of gravity were measured. Photographs were taken of the powered model with and without strips installed. A top view of the intakes is included in these photographs by means of a mirror.

The setup for the tests is shown in figure 5, with the model floating at take-off weight. The model was towed from its center of gravity about which it was free to trim. The model was also free to rise. Flaps were set at  $0^\circ$  for speeds below ski emergence and deflected  $20^\circ$  for speeds above ski emergence. The elevators were deflected up  $30^\circ$  because the controls could not be varied during the test runs, and this position of the elevators gave practical trims near take-off speed.

For the tests with power, compressed air for the jet unit was supplied by a hose which can be seen in figure 5. This installation, with normal operating pressure in the hose but with no air flow, was determined to have no measurable effect on the trim and rise of the model.

The method of measuring air inflow in the ducts consisted of measuring the static pressure at a point in one of the ducts (see fig. 3) close enough to the inlet so that the losses ahead of the station could be neglected and atmospheric pressure could be considered to be the total pressure at the measuring station.

The dynamic pressure  $q$  of the air in the duct was computed from the relation

$$q = p_t - p_s$$

where  $p_t$  is the total pressure, and  $p_s$  is the static pressure in the duct. The air velocity  $V$  was computed from this dynamic pressure using the air density  $\rho$  corresponding to the static pressure in the

duct and the temperature of the surrounding air. The inflow of air per duct  $W$  in pounds per second was computed from the relation

$$W = 0.9Ag\sqrt{V}$$

where  $A$  is the area of the duct at the measuring station and  $g$  is the acceleration due to gravity. The empirical constant 0.9 was assumed as a correction for the nonuniformity of velocity distribution across the duct. The mass flow measured by this method is believed to be within  $\pm 5$  percent of the actual value.

The turbojet thrust for the hypothetical airplane was assumed to be 3000 pounds (1.74 lb, model size). The thrust line is through the center of gravity used in these tests. The total air inflow at full thrust for a typical turbojet unit of this rating is about 55.0 pounds per second (0.11 lb/sec, model size). The actual values obtained during the model tests were 1.91 pounds thrust and 0.102 pound per second air inflow.

Some differences were found to exist between the data presented in reference 1 and the data obtained by the tests without power covered in this paper, even though the configurations were thought to be identical. Unpublished results of tests made to determine the cause of these differences showed that they were due to deformations which occurred to the model reported in reference 1. Deformation did not occur to the model reported in this paper as it was of sturdier construction.

## RESULTS AND DISCUSSION

Sequence photographs showing powered take-offs of the model are presented as figure 6. Without strips, spray entered the ducts over the speed range of 15 to 30 miles per hour (full size). The spray entering the ducts in the low-speed range clung to the sides of the fuselage until it entered the ducts. While this spray was readily observable, it was difficult to photograph. Therefore the photographs of figure 7 were retouched to illustrate more clearly this spray condition. Only a few stray drops entered the ducts during the transition when the skis emerged from the water (33 mph, full size). No spray entered the ducts at speeds above that of emergence.

In order to arrive at a type of strip that would be small and would keep the spray clear of the ducts, several types were tested. These strips are shown in figure 4 in the order tested.

With the short strips (type 1a) installed, spray came over the forward end of the strips and entered the ducts at 15 miles per hour (full size). The strips, however, kept the spray clear at higher speeds up to 25 miles per hour (full size). From this speed to the emergence speed, spray entered the aft portion of the ducts. Extension of the strips fore and aft (type 2a) kept the spray clear of the intakes except for the speed range from 25 to 30 miles per hour (full size). In this speed range spray was drawn into the aft portion of the duct with the power on but did not enter with the power off although the spray did come very close to the intakes. The strip was then rotated to make its lower surface normal to the fuselage (type 2b). With this arrangement the spray was kept clear of the intakes even with the power on. In an effort to find the smallest practical strips, types 2c and 2d were installed. The type 2c strips, which were only  $3/4$  inch wide full size, were effective in keeping the spray clear of the ducts. The type 2d strips deflected the spray to some extent, but small amounts still entered the ducts at speeds around 30 miles per hour (full size) even with the power off.

Of all the strips tested, type 2c was found to be the smallest type which kept the spray clear of the ducts with power on. With these strips installed, the spray was directed down and away from the model so it did not enter the ducts during the critical speed range of 15 to 30 miles per hour. (See figs. 6 and 7.) These abrupt strips were more effective than the sloping type 2a strips even though the sloping strips extended 40 percent farther from the fuselage.

There was no apparent difference in the spray near the intakes for runs made with and without power at speeds below 15 miles per hour (full size). However, from this speed to the emergence speed, the inflow caused by applying power made it necessary to extend the strips slightly farther aft than was required when no power was applied. This extension was necessary to prevent the spray from being drawn into the ducts.

The strips used to keep spray clear of the ducts had no measurable effect on trim.

The type 2c strips which kept the spray clear of the intakes were so small that their aerodynamic effect should be negligible, making retraction unnecessary.

The effect of jet power on trim and rise is shown in figure 8. Power increased trim approximately  $2^\circ$  at speeds above the speed at which the skis emerged. The cause of this change in trim was not determined, but it appears to be an aerodynamic rather than a hydrodynamic effect.

Although take-off stability limits were not determined, the application of power had no noticeable effect on stability. All take-off runs were stable.

## CONCLUSIONS

Tests with a jet-powered dynamic model of a hypothetical high-speed airplane fitted with hydro-skis and having flush turbojet intakes on the upper part of the fuselage indicate the following conclusions:

1. Very small longitudinal strips (only 3/4 in. wide, full size) are required to keep spray from entering the jet intakes during take-off.
2. The tendency of the turbojet air inflow to draw spray into the intakes is slight.
3. Jet power increased trims approximately 2° during the high-speed part of the take-off run.

Langley Memorial Aeronautical Laboratory  
National Advisory Committee for Aeronautics  
Langley Field, Va.

## REFERENCES

1. Dawson, John R., and Wadlin, Kenneth L.: Preliminary Tank Tests of NACA Hydro-Skis for High-Speed Airplanes. NACA RM No. L7I04, 1947.
2. King, Douglas A.: Tests of the Landing on Water of a Model of a High-Speed Airplane - Langley Tank Model 229. NACA RM No. L7I05, 1947.

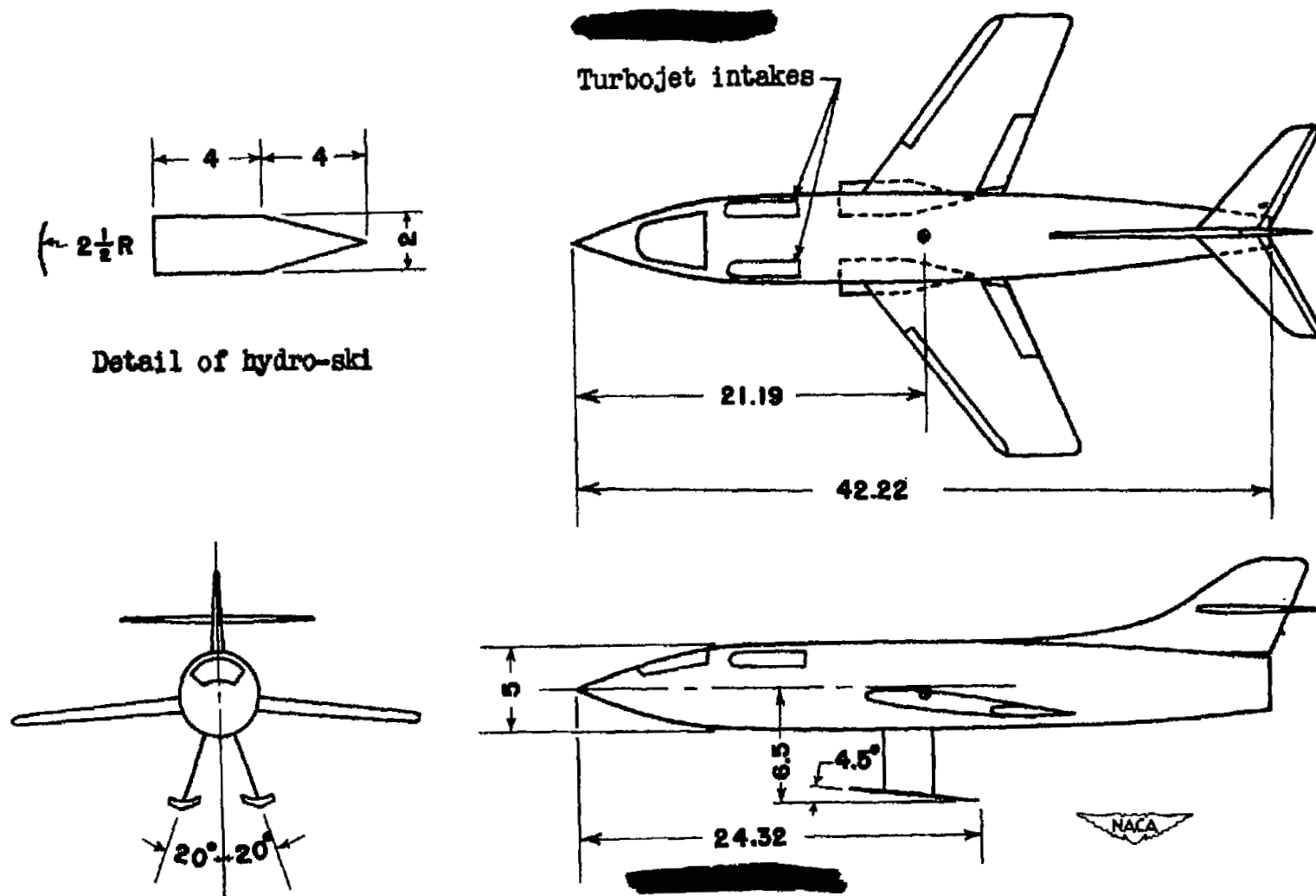


Figure 1.- Drawing of model fitted with NACA hydro-skis. (Dimensions are feet, full size; and inches, model size.)

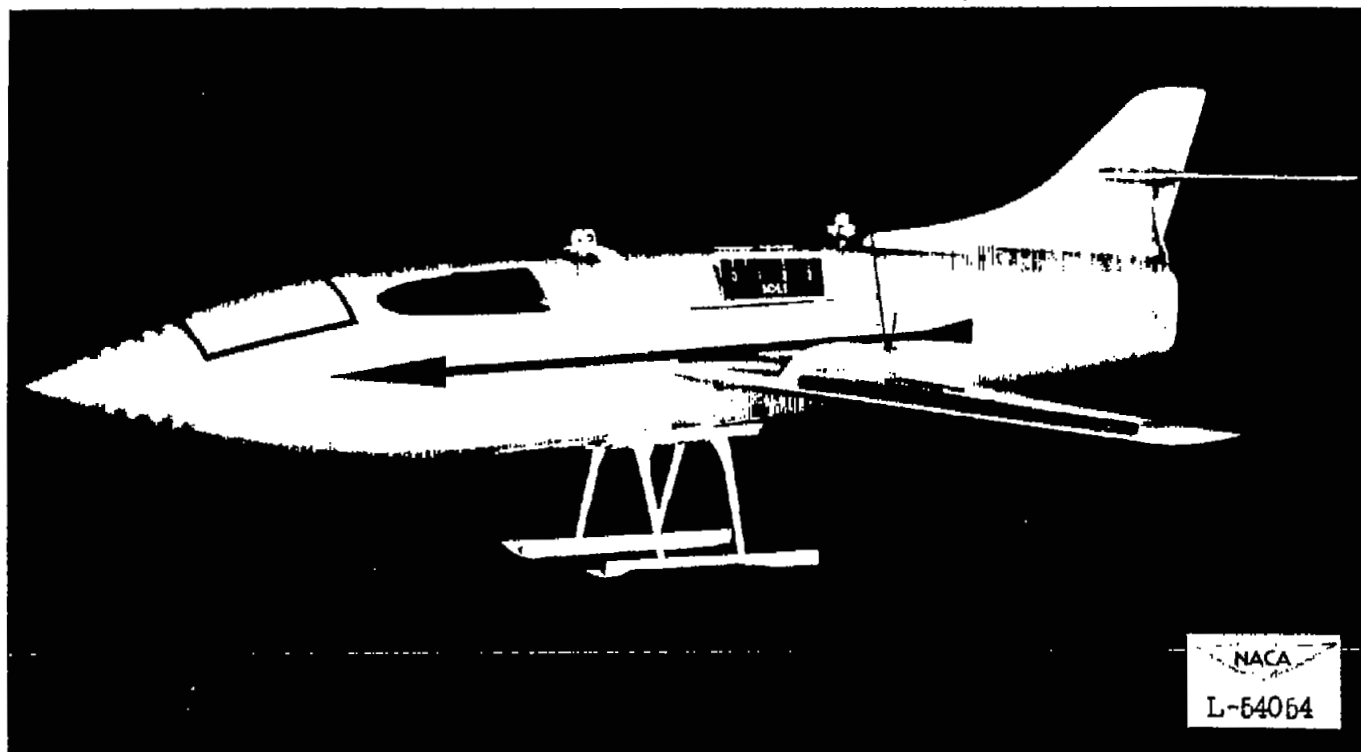


Figure 2.- Photograph of model fitted with NACA hydro-skis.





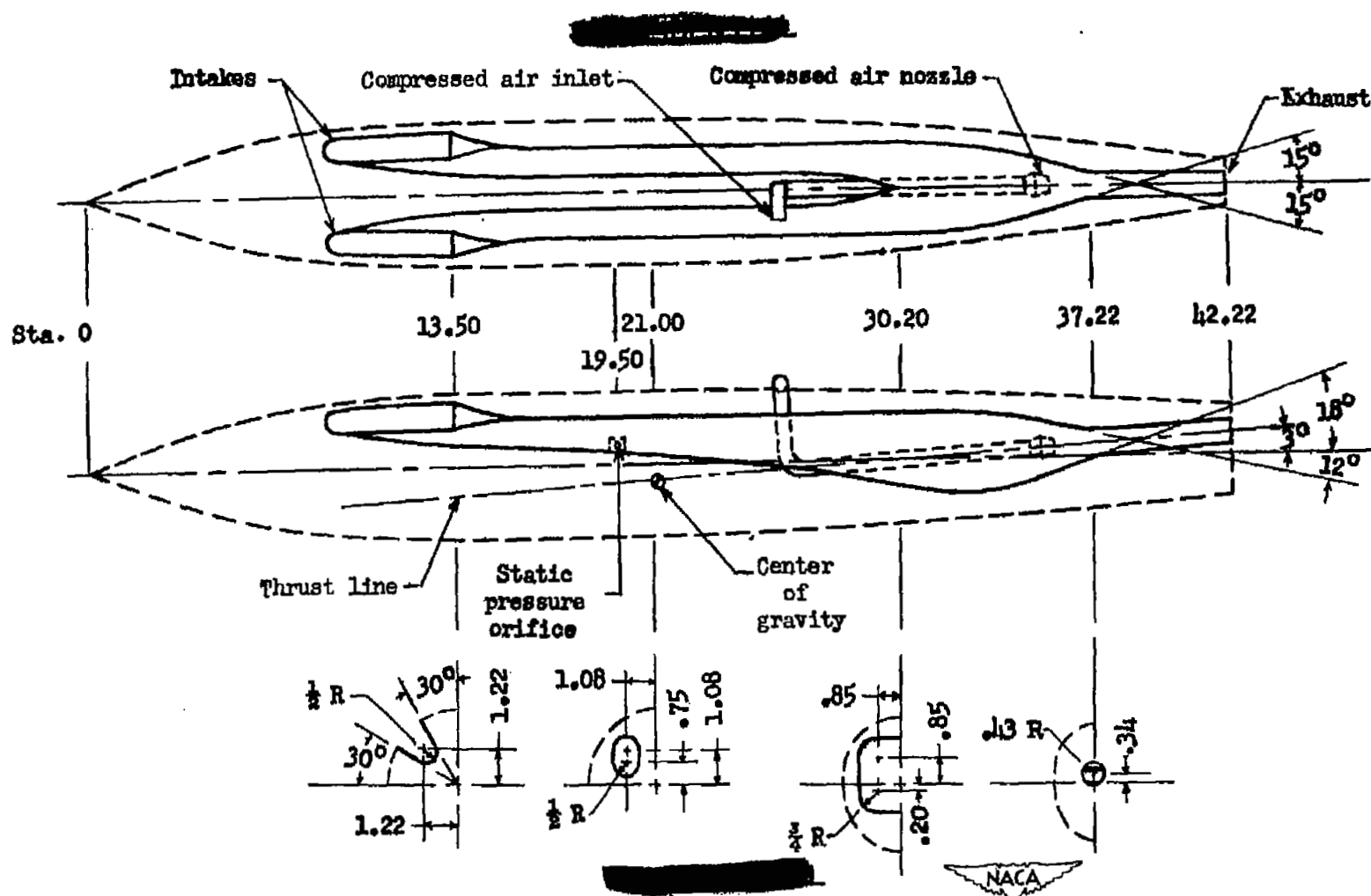


Figure 3.- Model jet unit details. (Dimensions are inches, model size.)

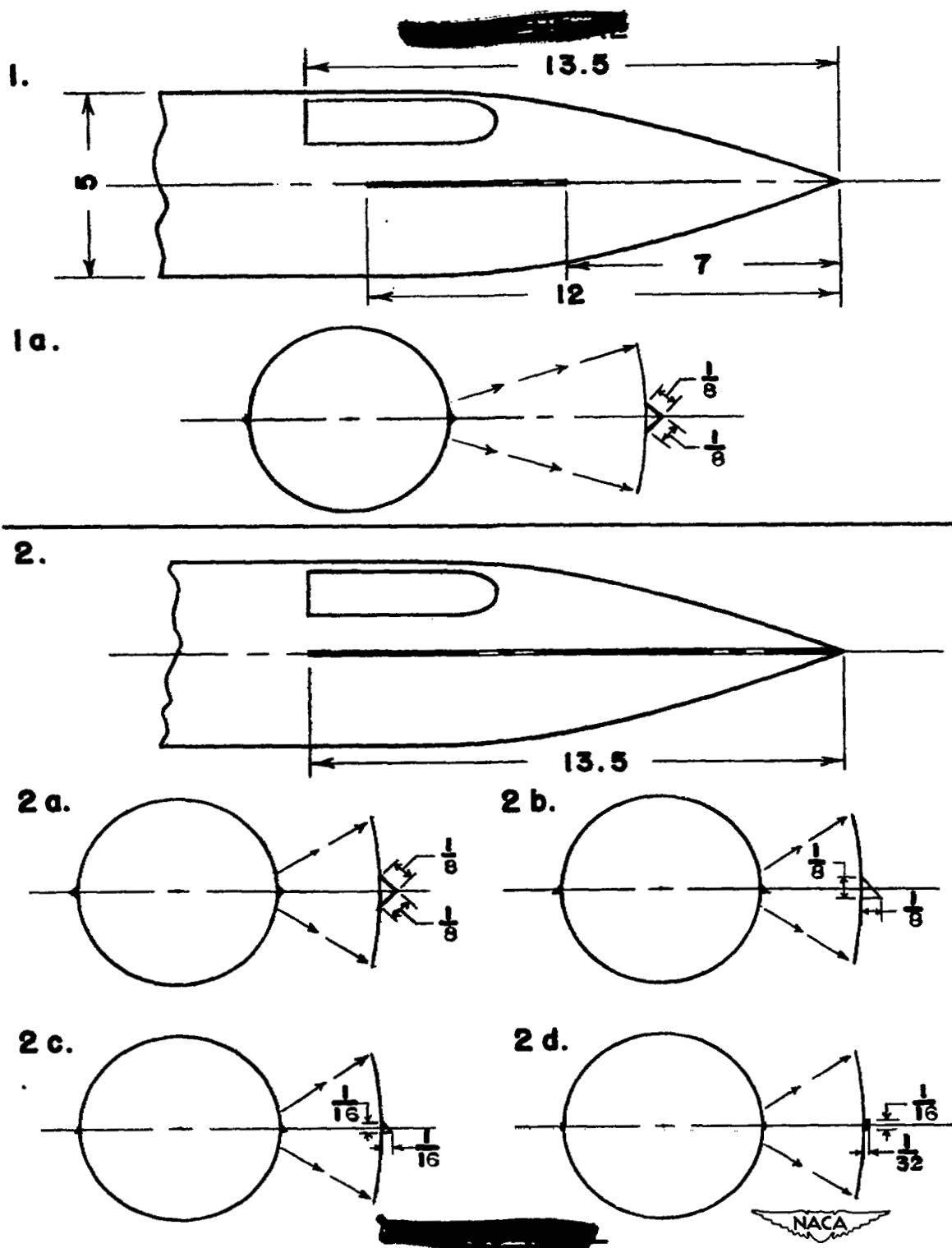


Figure 4.- Details of strips tested. (Dimensions are feet, full size; and inches, model size.)

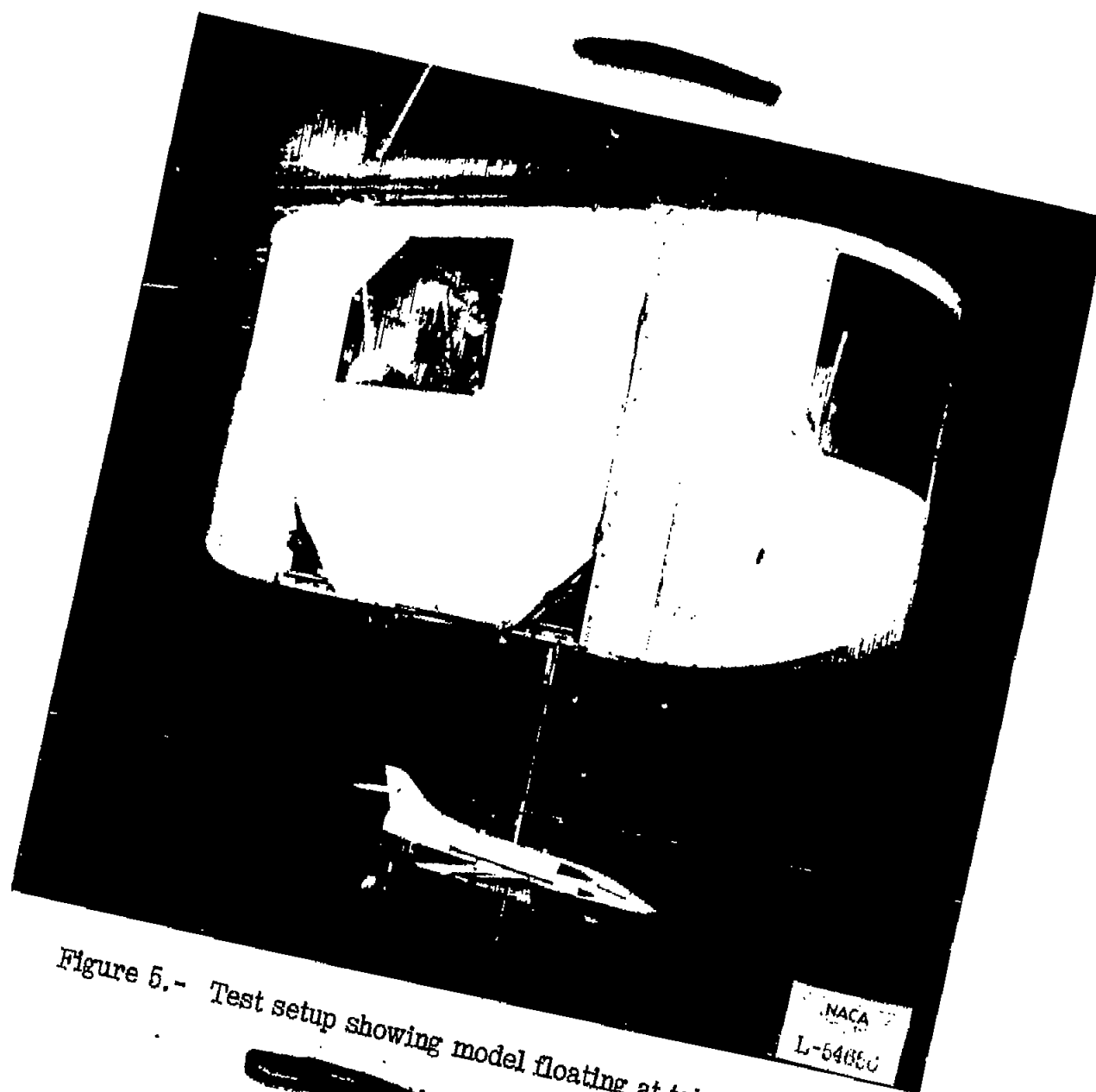


Figure 5.- Test setup showing model floating at take-off weight.





At rest



14 mph



28 mph

Without strips



At rest



14 mph



28 mph

With type 2c strips

Figure 6.- Sequence photographs of typical powered take-off runs with and without strips installed. (Speeds are full size.)



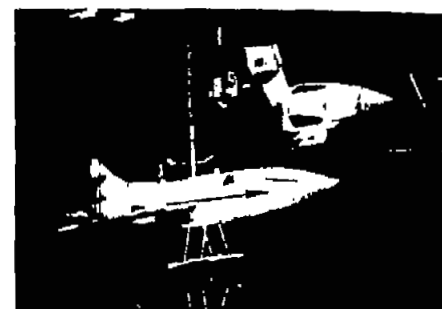




33 mph



70 mph



130 mph

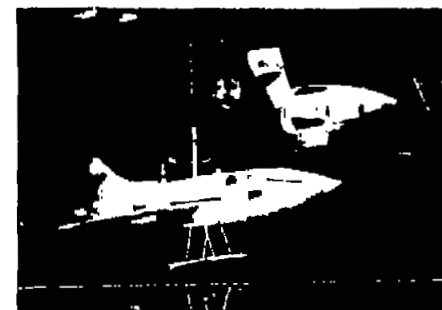
Without strips



33 mph



70 mph



130 mph

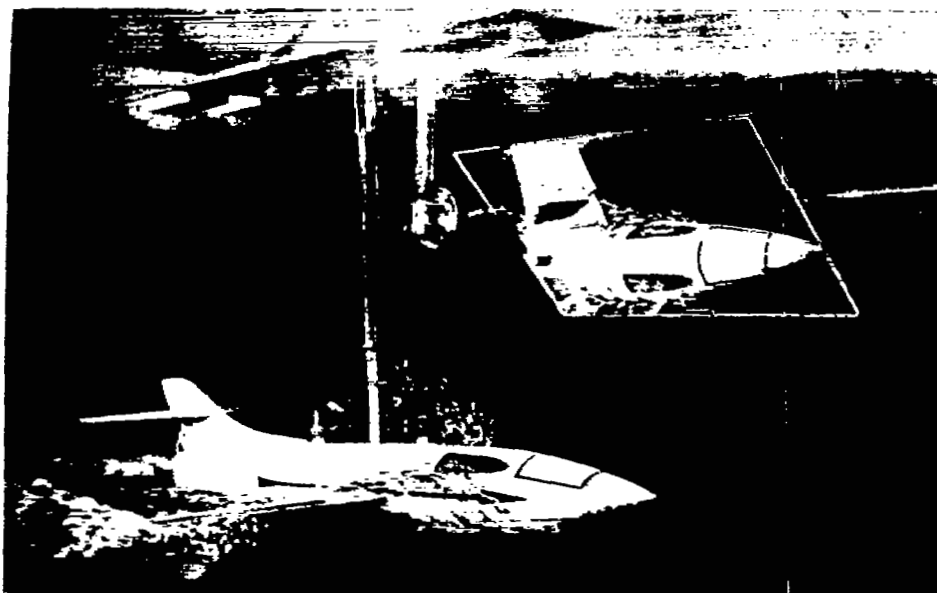
With type 2c strips

Figure 6.- Concluded.

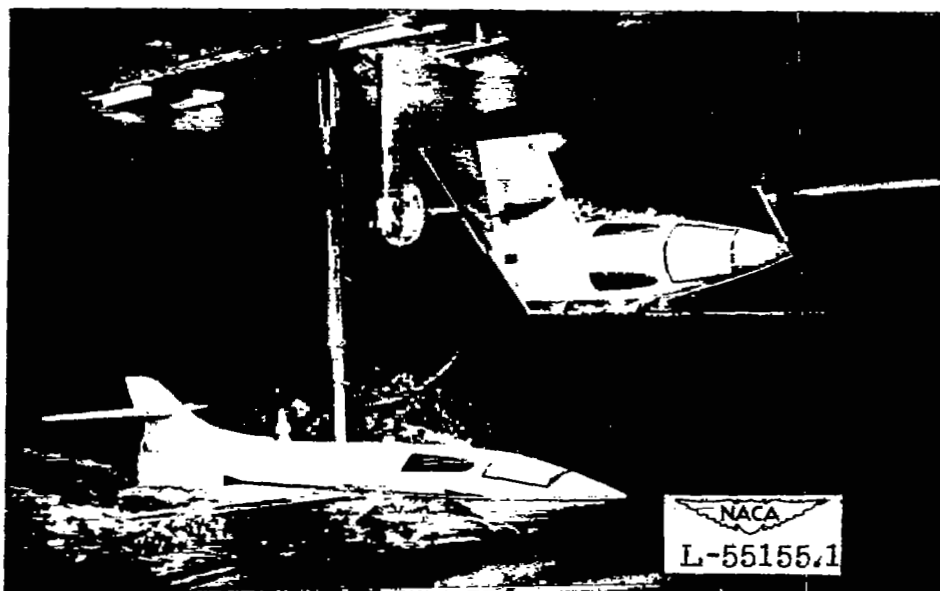








Without Strips



With type 2c strips

Figure 7.- Retouched photographs of critical spray condition (28 mph, full size).



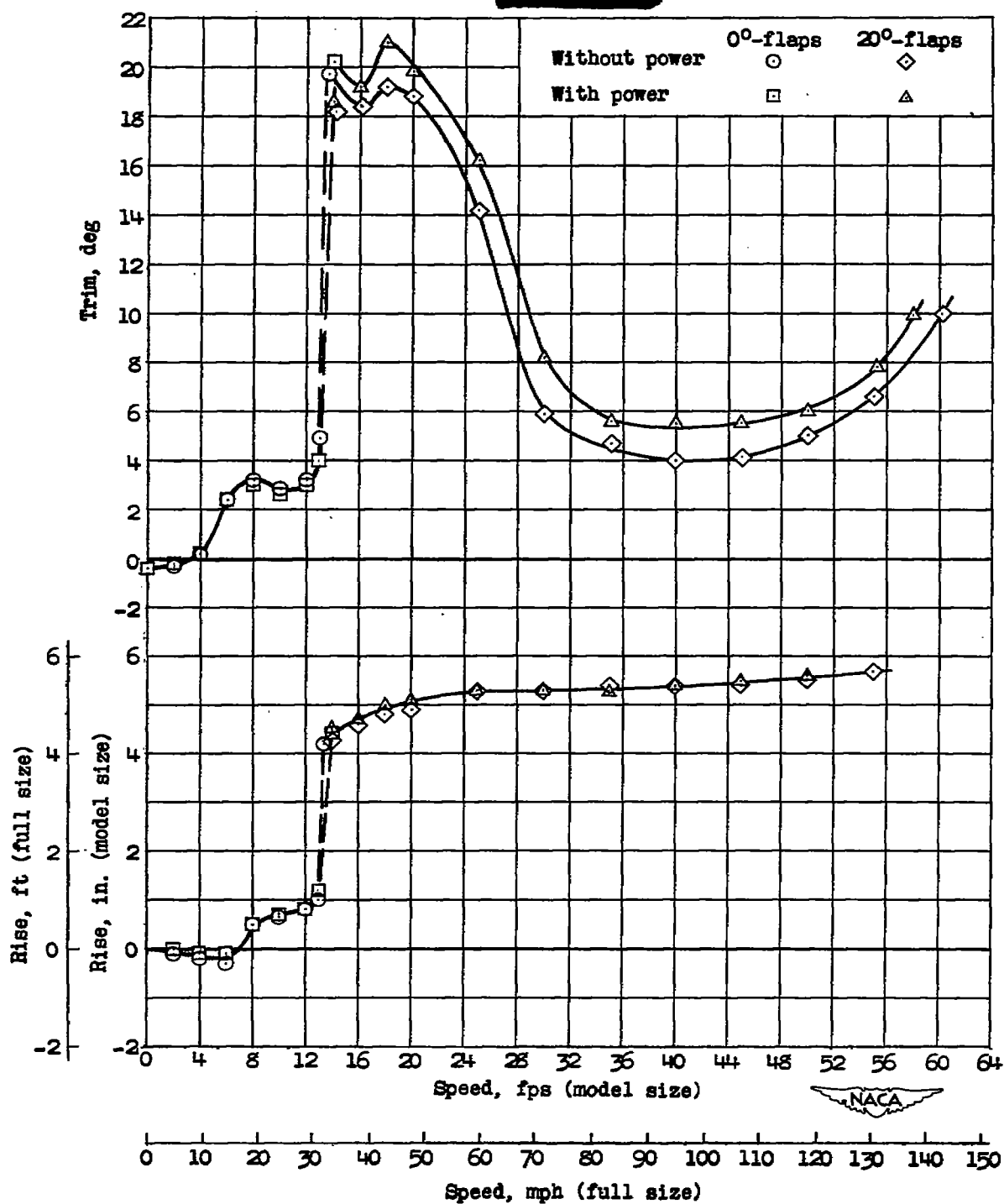


Figure 8. - Effect of jet power on trim and rise.

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